A PROCESS FOR KEEPING A TUYERE PASSING THROUGH A METALLURGICAL VESSEL FREE OF A SKULL

Background of the invention

The invention relates to a process for the keeping free a tuyere passing through a metallurgical vessel of a skull by intermittendly passing an oxygen-containing gas through the tuyere to dissolve the skull.

A common method to measure the temperature of molten metal in a container, such as e.g. a metallurgical vessel, is by means of a pyrometer. Normally, a non-contacting type radiation pyrometer is arranged at the end of a nozzle base which is part of a gas blowing tuyere. The tuyere is arranged at the bottom or at the side wall of the metallurgical vessel. The pyrometer can also be arranged at one end of a measuring channel introduced into the melt from the top of the metallurgical vessel. Such arrangements are e.g. disclosed in DE-OS 964 991, DE-A-4 025 909, EP-A-0 362 577, US-A-3 161 499, EP-A-0 162 949, DE-OS-2 438 142, US-A-4 400 097 and JP-A-62 207 814.

Generally non-reactive gas is blown through the tuyere into the inside of the melt to keep its opening free. Nevertheless, skulls may build up in the measuring channel since metal freezes at the outlet of the tuyere so that the measuring channel is clogged from time to time. The frozen metal at the outlet of the tuyere may be dissolved by means of blowing oxygen through the channel. In this way the clogging of the tuyere may be prevented. However, oxygen distorts the measured values considerably and promotes wear of the measuring channel. Therefore, oxygen must be blown intermittendly through the channel.

Summary of the invention

The object has been solved by a process for keeping a tuyere passing through a metallurgical vessel free of a skull by intermittendly passing an oxygen-containing gas through the tuyere to dissolve the skull, wherein it is determined that an interval for passing the oxygen-containing gas through the tuyere needs to be started by detecting electromagnetic radiation emanating from a spot in the interior of the melt by means of a dual wavelength pyrometer and comparing the intensity of the pyrometer signals with the ratio of the pyrometer signals, and initiating the interval for passing the oxygen-containing gas through the tuyere, upon the condition that the combined intensity of the signals falls below a predetermined threshold value and that the ratio of the signals remains substantially constant. Preferably the threshold value is determined by using a video camera which is arranged with the pyrometer along one optical path and by setting into relation the intensity of the pyrometer signal with the image of the video camera, deciding on the basis of the video image whether a status of clogging is reached and determining the corresponding intensity value of the combined pyrometer signals.

Another object has been solved by providing an apparatus which includes:

(a) a dual wavelength pyrometer,

(b) an autofocus video camera which is aligned with the dual wavelength pyrometer along one optical path,

(c) means for varying the orientation of the optical path, and

(d) optionally a further detector for measuring electromagnetic radiation emanating from the interior of the vessel.

Preferably the apparatus further includes a laser device suitable for creating a plasma in the interior of the metallurgical vessel, and wherein the further detector is a spectrometer capable of detecting electromagnetic radiation emanating from the plasma. More preferably, the apparatus is connected to the interior of the metallurgical vessel by means of a tube which is passed through the tuyere.

Detailed description of the invention

Figure **1** shows a preferred configuration of the apparatus of the present invention. The apparatus **1** is connected to a container **2** such as a metallurgical vessel containing a melt, preferably a molten metal. The container **2** is preferably a converter. A blowing lance may be inserted into the melt from the top for blowing oxygen into the melt, thereby converting iron into steel. Alternatively, the oxygen many be blown into the converter through tuyeres at the bottom and/or side walls of the container **2**. The apparatus **1** is connected to the inner side of the container **2** via a tuyere. The tuyere forms a measuring channel **A** through which electromagnetic radiation emitted from the inner side of the container may pass. The tuyere has one end facing the interior of the container. The second end of measuring channel **2** faces a first measuring unit **3** which preferably includes a dual wavelength pyrometer and a video camera. Preferably a spectrometer **4** and a laser generating unit **5** are also connected to the measuring channel. Most preferably data processing devices **6** are connected to the measuring unit **3**.

Figure **2** schematically shows a detailed cross sectional and bottom views of the measuring channel (which indicated as **A** in Figure **1**). Electromagnetic radiation may pass unhindered through the unobstructed measuring channel **7**, as schematically shown in the bottom view **8**. Once clogging occurs at the top of measuring channel **9**, the passage of electromagnetic radiation is hindered, as schematically shown in bottom view **9**. Measuring unit **3** can not anymore detect the intensity of

electromagnetic radiation of the whole area of the channel.

Figure **3** shows in detail, how the measuring channel (indicated as **A** in Figure **1**) can be formed. Preferably a set of two concentric tubes is used. The measuring channel preferably includes an outer tube **11** and an inner tube **12** such that different gases or gas mixtures can blown into the container. For example a gas stream **13** comprising nitrogen-gas and/or argon, and methane may be passed through the inner tube **12**, whereas a gas stream comprising nitrogen-gas and/or argon, and oxygen may be passed through the outer tube. Inner tube **12** also forms the measuring channel. Thereby oxygen cannot affect measuring.

Figure **4** schematically shows a preferred embodiment of measuring unit **3** (Fig. **1**). It includes an adjustable lens **15**, two adjustable mirrors in combination with two pyrometer detectors **16**, **17** and a detector **18** for collecting a video signal. Adjustable lens **15** is preferably an autofocus lens and driven by a motor (not shown).

The process for determining the interval for passing the oxygen-containing gas through the tuyere is started by detecting electromagnetic radiation emanating from a spot in the interior of the melt by means of a dual wavelength pyrometer and comparing the intensity of the pyrometer signals with the ratio of the pyrometer signals. The interval for passing the oxygen-containing gas through the tuyere is initiated upon the condition that the combined intensity of the signals falls below a predetermined threshold value and that the ratio of the signals remains substantially constant. The threshold value needs to be pre-determined only once visually on the basis of the image of the video signal. On the basis of the image it is decided whether the status of clogging is reached, and the corresponding intensity of the combined pyrometer signals is determined. This threshold value is then used for automatic initiation of the intervall for passing the oxygen-containing gas through the tuyere.

The concept that resides in the use of a dual wavelength pyrometer instead of a standard pyrometer. In addition to the information about the intensity of each of the two wavelengths that are measured, a quotient of two wavelengths can be calculated.

This creates additional information, which can be used to determine the point in time at which oxygen has to be blown through the measuring tuyere. If only the intensity of one wavelength is measured it is not possible to decide whether the change in the intensity is caused by a change of the temperature of the melt or because a skull is being formed at the end of the tuyere. By measuring the intensities of two wavelengths and correlating them with each other, e.g. by forming the quotient of both values, information can be obtained about the reason of such a change. For example, if the values of the measured intensities both fall but the quotient of these values is about constant, it can be assumed, that the tuyere is being clogged by a skull, whereas, e.g., in case the values of the measured intensities both fall but the ratio of both intensities is changing, it can be assumed, that the temperature of the melt is changing.

Therefore it is an advantage of the process according to the present invention, that oxygen is not unnecessarily blown through the measuring channel only because the intensity of the pyrometer signal falls below a predetermined threshold value.

It has surprisingly turned out that with such embodiment it is also possible to adjust the optical axis of the instrument for measuring electromagnetic radiation, such as the pyrometer and the spectrometer.

To adjust the one or more measuring devices, with a dual wavelength pyrometer and/or a spectrometer being preferred, its/their optical axis/axes is/are moved until the near end of the measuring channel and the perspective image of its far end is depicted in a regular fashion according to the geometry of the measuring channel, e.g. a regular tubular measuring channel will result in a circular image. This adjustment is preferably performed using the video camera. For this purpose the video camera and the instrument for measuring electromagnetic radiation are arranged along one optical path.

The adjustment is carried out on the basis of the video image by varying the orientation of the instrument(s) and the video camera such that the first end and second end in the video image form concentric circles is another object of the present

invention.

The optimal position of the measuring device(s), i.e. the dual wavelength pyrometer and/or the spectrometer is reached when the geometries of both ends of the measuring channel depict concentric images, i.e. in case of the above mentioned (as an example) tubular measuring channel concentric circles would have to be obtained. To visualize the "near end" of the measuring channel, i.e. the end of the measuring channel that is directed to the measuring device(s) and the camera, it is advisable to use an auxiliary source of light.

It has surprisingly been found out that with the present configuration it is also possible to measure the length of the tuyere passing through the metallurgical vessel **3**. This information is important because it is an indication of the wear of the lining of the container. The information is also needed for focussing the laser beam.

For this purpose, the lens system of the autofocus video camera is adjusted so that the first end of the tuyere facing the interior of the metallurgical vessel is in focus. The length of the tuyere is determined on the basis of the distance of the focus and the known position of the second end of the tuyere with respect to the camera.

With this information, the laser beam can be focussed in such a way, that a intensity that is sufficient to form a plasma, the radiation of which can be detected by the spectrometer, is only present at the surface of the melt to be analyzed or inside the melt, but is not inside the gas cavity formed by the gas blowing through the measuring channel.